EVALUATING SOYBEANS

by dielectric analysis and other methods

Marketing Research Report No. 367

UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Marketing Service Marketing Research Division

PREFACE

The study on which this report is based is a part of a broad program of research by the Marketing Research Division, Agricultural Marketing Service, to improve efficiency in the marketing of farm products and to expand their markets.

This report is an amplification of a preliminary report on the same subject (AMS-229, U. S. Dept. Agr., Agr. Mktg. Serv.) released in February 1958. The earlier report presented information concerning the relative accuracy of soybean oil content estimates based on the official grade factors, compared with estimates based on the dielectric analysis method for the 1955-56 marketing season. Now the study has been expanded to include results based on analysis of similar data for the 1956-57 season. It also includes information concerning variation in oil content determinations obtained by approved chemists at commercial laboratories using the official method of the American Oil Chemists' Society.

The soybean samples for this study were drawn from carload lots upon arrival at a grain elevator and two processing plants in the Midwest. The beans were graded by federally licensed grain inspectors. Electronically determined data on oil content were supplied by an elevator, a processor, and the Agronomy Department of Iowa State College. A commercial laboratory supplied data on oil content and other results of soybean analyses, based on official methods. Other data used in the report were furnished by R. T. Doughtie, Jr., Cotton Division, Agricultural Marketing Service.

Fred Stein Laboratories, Atchison, Kans., manufacturers of the grinder-extractor and the electronic oil tester, instructed nontechnical personnel in the use of their equipment.

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SUMMARY

On the basis of two years of field testing of the dielectric method of determining the oil content of soybeans, it is concluded that further modifications of test equipment and procedure are needed before this method can be generally used and accepted by the trade.

The dielectric method has the advantages of being simple, relatively low in cost, and capable of an accuracy in measuring oil content similar to that which this study shows can be obtained by estimating oil content from the present grade factors. Furthermore, the dielectric method provides a specific reading of oil content, whereas estimating oil content on the basis of grade factors requires the use of estimating formulas which would be cumbersome to employ in commercial practice.

On the other hand, further research now in progress is expected to result in the development of an improved dielectric oil tester yielding results under commercial conditions approximating the relatively high degree of accuracy of the standard gravimetric method generally accepted by the trade. Then it might be considered economically feasible to use the modified dielectric method for determining oil content as an adjunct to the soybean grade standards, to provide a mechanism for more equitable pricing of this commodity.

Though the oil content is a major value-determinant of soybeans, the Official Grain Standards used in grading soybeans do not take oil content into account. Meal content of soybeans also affects their value, but since it generally varies less than oil content and is worth less per pound, the variation in soybean product value is indicated principally by variation in soybean oil content.

The primary purposes of this study were, first, to examine the feasibility of improving the grading of soybeans by using the rapid dielectric method to determine oil content, and, second, to indicate the costs of using this method and the effects its use might have on producer prices for soybeans.

Analysis showed that the official grade factors, where used, tend to give some indication of the relative quantities of oil in the beans. At the three Midwest test sites, for a 2-year period covered by this study, two-thirds of the oil content estimates based on the soybean grade factors ranged within 0.23 to 0.38 pound of the corresponding oil content (per bushel of soybeans) chemically determined at a commercial laboratory. Generally the soybeans in the higher grades had a greater average oil content than the beans in the lower grades. In 4 of 11 cases for the first year, and in 1 of 12 cases for the second year, however, the average oil content for a given grade was less than that for the next lower grade, though these differences were small.

In addition to certain minor gradations of oil content between successive grades, oil content varied considerably within most soybean grades. The average of the variation of oil content within grades ranged from 0.32 pound of oil per bushel of beans for the Sample grade to 2.1 pounds of oil per bushel for grade No. 2. Thus, the prices paid for soybeans at the elevator may closely approximate the actual value for the total of soybeans purchased. But the individual farmer selling soybeans with high oil content may be paid too little and the one with beans of a low oil content may be overpaid.

The rapid dielectric method permits nontechnical personnel, after receiving brief instructions, to determine oil content of individual samples within 15 minutes at an estimated cost of 54 cents each. In comparison, the standard laboratory method requires at least 8 hours before individual test results of a battery of samples being tested are available, and the cost is estimated at $1.19 per sample. At the three test sites for the two marketing seasons, two-thirds of the estimates based on the dielectric oil determinations ranged from 0.24 to 0.36 pound of the corresponding oil determinations by the standard laboratory method. At the average price of soybean oil for the two marketing seasons, these differences in oil content determinations between the two methods represent values of 3.0 to 4.5 cents per bushel of soybeans.

The average difference in soybean product value (oil and meal) between grades No. 1 and No. 2, based on the dielectric oil test results for the two marketing seasons, was 1.7 and 1.5 cents per bushel of soybeans, whereas the average difference based on laboratory oil determinations for the 2 seasons was 2.5 and 1.7 cents per bushel.

Approximately 70 percent of the variation in results of the dielectric oil test from those by the standard method for the first year and about 67 percent for the second year were attributed to four discernible causes. These apparent causes of variation included: Differences in adjustment and a gradual change in the electronic balance of the three oil testers; dulling of the grinder-cutter blades; differences in the average temperature of the test cells and solvent; and insufficient warmup and inadequate cleaning of the test cells.

Some variation in oil content determinations for a given sample of soybeans can be expected even when the official method of the American Oil Chemists' Society is used by Government-approved chemists. An analysis of the variation of oil content determinations among commercial laboratories for soybean check

samples, for the seasons 1946-47 through 1957-58, indicated that, for the season in which the least variation occurred, about two-thirds of the test results come within 0.11 pound of oil of the accepted standard. For the season in which the greatest variation occurred, about two-thirds of the oil tests came within 0.20 pound of oil of the accepted standard. For most years, however, the variation in these results was within 0.14 pound of oil.

INTRODUCTION

The objectives of this study were to determine: (1) The extent to which existing marketing methods and grades reflect the soybean quality characteristics that are valued most by processors, marketing agencies, and producers; (2) the economic feasibility of utilizing the rapid dielectric oil-determining method to improve the grading and pricing of soybeans at the farm market level; and (3) the relative accuracy of the standard laboratory method for determining oil content, used as the basis for comparing results of the first two methods.

Soybean farmers have lacked the opportunity to market their soybeans strictly according to the value of the oil and meal they yield. Most country elevator operators use a rather informal and unofficial grading procedure in estimating the value of a farmer's soybeans. While experienced elevator operators can become quite proficient in the use of this "grading" procedure, there is considerable room for improvement. The growers, country elevator operators, and processors all need more complete information concerning the causes and indicators of variations in the quantity and quality of soybean products if soybeans are to be traded at prices more in line with their true value.

Soybeans and the products they yield are subject to variations in quantity and quality which affect their value and utility. Recognition of this is reflected in the use of the U. S. Official Grain Standards, which provide a basis for trading soybeans. However, even where the official grade standards are used, they do not take the oil content into account in soybean grading, although oil is a major value-determinant of soybeans. Meal content of soybeans also affects their value, but, since it generally varies less than oil content and is worth less per pound, the variation in soybean product value is indicated principally by variation in soybean oil content. While processors may analyze soybeans for oil content, or obtain this service from commercial laboratories, elevator operators rarely, if ever, do. In any event, oil content is not used as a direct basis for purchasing soybeans from farmers. Thus, interest has focused on the development of a rapid method for determining oil content for possible use in improving soybean grading. By knowing the percentage of oil content in addition to the percentages of foreign material and moisture (two of the present grade factors), the elevator operator could easily calculate the yields of oil and meal for individual lots of soybeans. This would permit the pricing of soybeans on the basis of expected product outturns.

A rapid method for oil content determination which shows promise for use in reducing the margin of error in pricing individual lots of soybeans at the

country elevator is called the "dielectric method." 1/ This relatively new method utilizes electronic oil-testing equipment which permits nontechnical personnel, after brief instruction, to determine the oil content of individual samples within about 15 minutes.

The dielectric oil tester has been used to some extent in the trade for testing soybeans for oil content shortly before harvest, to determine areas from which beans with high oil content can be expected. Also, it has been used for rapid testing of individual carlots of beans arriving at processing plants and for certain plant control work, including the testing of press cake for residual oil. While firms that have used the dielectric oil tester generally regard it as useful for certain purposes, variations in results obtained with it have led to a question whether or not it should be used as an adjunct in grading at the farm market level.

In terms of volume of output and of farm value, the soybean is the principal oilseed crop of the United States. It is also this country's leading source of vegetable protein. The expansion of soybean production in this country has progressed at a phenomenal rate, particularly during the last 17 years. Domestic soybean production in 1941 was around 107 million bushels, valued at about $166 million, whereas in 1958 it was around 575 million bushels valued at about $1,136 million, on the basis of the average prices received by growers. The rapid growth of the soybean industry has been enhanced by the development and adoption of improved seed and farming practices, more efficient processing techniques, and the ability of expanding markets to absorb soybean products at competitive prices.

The outturns of oil and meal from a bushel of soybeans are generally about equal in value, the meal being only slightly higher in value than the oil. (During the 1957-58 marketing year, the ratio of the value of meal to oil per bushel of beans was 1.1 to 1.) However, a pound of oil is worth several times as much as a pound of meal. During the 1955-56 marketing year, soybean oil was worth 4.7 times as much per pound as soybean meal. During the following 2 marketing seasons (1956-57 and 1957-58), the oil was worth 5.4 and 4.1 times more, respectively, per pound than meal. As long as this value relationship persists, processors will continue to want soybeans with high oil content and growers will be interested in producing such beans to the extent that prices properly reflect the differences in the value of their components.

1/ "Dielectric" refers to material that does not conduct electric current. When a dielectric material is placed between two electrodes a certain force exists which is a constant for a particular material. The addition of oil (from finely ground soybeans, for example) to a solvent results in a change in the dielectric constant which is proportional to the amount of oil added. The dielectric oil tester (Steinlite LOS unit) measures these changes. Then prepared conversion tables are used to translate meter readings into the percentage of oil in soybeans. The method also is applicable to other oilseeds. Mention of the Steinlite unit does not constitute Department endorsement of it over other manufacturers' products having a similar function.

DATA USED AND METHODOLOGY

Soybean samples analyzed in the study were collected at three commercial plants, two in Iowa and one in Illinois. At each of these three locations, samples were drawn at irregular intervals from carload lots received by the firms in the normal course of business during the 1955-56 and 1956-57 soybean marketing years. In the first season, 493 samples were tested, and in the second, 447. The samples were grown in the principal soybean-producing area of the North Central region. The varieties represented were not identified and in most cases the point of origin was not given. Those samples for which the origin was given, however, were from Illinois, Iowa, Minnesota, and Missouri.

The samples, weighing about $2\frac{1}{2}$ pounds each, were collected at a grain elevator and two processing plants by federally licensed grain inspectors. The samples were inspected and graded, and the result for each grade factor (test weight, moisture, splits, damaged soybeans, and foreign material) was recorded on the inspection certificate. Each sample was thoroughly mixed and divided into two parts. One part, weighing about $\frac{1}{2}$ pound, was retained at each of the three test sites, where a 100-gram portion was tested electronically for oil content by the rapid dielectric method. One of the Iowa firms sent its samples to Iowa State College for testing.

At each of the three test sites, the remaining portion of each sample (weighing about 2 pounds), together with a copy of its grade certificate, was placed in a moisture-proof container and sent to a commercial laboratory for analysis. From the laboratory analyses, the following information was obtained for each sample: Percentage of oil, moisture, and protein content of the beans, and free fatty acid content (as oleic acid); iodine number (Wijs); and color (Lovibond and photometric) of the oil. Analysis of the data for the last three of the above tests, however, was not included in this report.

The relationship of laboratory-determined oil content to the U. S. soybean grade factors was determined statistically. The relationship between the soybean oil content data obtained by the dielectric and standard laboratory methods also was determined. The difference between the laboratory-determined oil content and estimates of oil content based on the official grade factors, as described later in this report, was then converted to weight of oil per bushel and then to monetary value per bushel. This procedure was applied also to the difference between the dielectric and laboratory oil content determinations. Further analysis was then made of these latter data to determine and measure the sources of variation in the dielectric oil content determinations.

The soybean samples were then classified by grades and an analysis of the data obtained for the samples was made to determine the variation in oil content as well as the differences in the average soybean product value for each grade.

The results of these analyses were used for comparing the relative accuracy of oil content estimates based on the official grade factors with that of estimates from the dielectric oil tests.

Also, an analysis was made of oil content determinations obtained by Government-approved chemists for soybean check samples, to determine the variation occurring in oil test results obtained when different chemists each employ the official method of the American Oil Chemists' Society. This was done because the oil test results by the dielectric method were compared with corresponding results by the official method as the standard.

EVALUATING SOYBEANS FROM UNITED STATES OFFICIAL GRADE FACTORS

Recognition of variation in the quality and condition of soybeans accounts for the use of official grade standards to provide a basis for trading in this commodity (table 1). Before the soybean became a major agricultural crop in the United States, it was placed with the cereal grains for grading purposes. And though the soybean differs in certain respects from the other commodities in this classification, the trading in soybeans is regulated under an act of Congress referred to as the "United States Grain Standards Act."

In addition to the variation of soybean quality and condition, there is variation in the quantity of oil and meal that soybeans yield. Variations in oil and meal content caused the combined value of oil and meal to vary 15 cents per 60-pound bushel during the 1955-56 processing season and 36 cents during the 1956-57 season.

Appraisal of the quantities of oil and meal that can be recovered from soybeans assists the processor in determining the price he can afford to pay the seller. The extent to which the official soybean grades reflect differences in soybean product value affects the confidence with which the grades may be used for evaluating soybeans in trade channels.

Processors generally rely on the grade factors to reflect the quality and quantity of products obtained from soybeans. On September 1, 1955, they began buying soybeans on the basis of No. 1 grade (instead of No. 2), and soybeans not meeting the requirements for No. 1 are discounted according to their individual grade factors.

Because the official soybean grades are used as the basis for much of the trading in soybeans 2/, an attempt has been made to determine the relationship between oil content and the grade factors which comprise the official grain standards of the United States as applied to soybeans. The relationship between laboratory-determined oil content and oil content estimates based on

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2/ All soybeans sold by grade and moved from one inspection point to another in interstate commerce must be inspected and graded.

Table 1.--Official U. S. grades and grade requirements for all classes of soybeans

Grade	Minimum test weight per bushel	Maximum limits of--					
		Moisture	Splits	Damaged kernels		Foreign material	Brown, black, and/or bicolored soybeans in yellow or green soybeans
				Total	Heat damaged		
	Pounds	Percent	Percent	Percent	Percent	Percent	Percent
No. 1	56	13.0	10.0	2.0	0.2	1.0	1.0
No. 2	54	14.0	20.0	3.0	.5	2.0	2.0
No. 3 1/	52	16.0	30.0	5.0	1.0	3.0	5.0
No. 4 2/	49	18.0	40.0	8.0	3.0	5.0	10.0
Sample grade	Sample grade shall be soybeans which do not meet the requirements for any of the grades from No. 1 to No. 4, inclusive; or which are musty, sour, or heating; or which have any commercially objectionable foreign odor; or which contain stones; or which are otherwise of distinctly low quality						

1/ Soybeans which are purple mottled or stained shall be graded not higher than No. 3.
2/ Soybeans which are materially weathered shall be graded not higher than No. 4.

Source: Official Grain Standards of the United States, 1957, p. 70, U. S. Dept. Agr.

official grade factors is discussed early in the report to provide a basis for comparing the relative merits of the rapid dielectric method in evaluating farmers' soybeans.

Estimating Oil Content from Soybean Grade Factors

The oil content of 171 soybean samples of the 1955-56 season and 149 samples of the 1956-57 season, selected at random at the three test sites, was estimated from the following grade factors: Test weight, and percentages of moisture, splits, and foreign material per bushel of soybeans. Damage as a grade factor was not included because there were not enough damaged beans for comparable analysis. At the three test sites for the 1955-56 season, approximately two-thirds of the estimates 3/, based on the grade factors, ranged within 0.38 to 0.53 percentage point of the oil content determined at the commercial laboratory (table 3). These percentage points of oil converted to weight per 60-pound bushel represent differences among locations of from 0.23 to 0.32 pound of oil between the oil estimates and the laboratory-determined oil content. 4/ At the average price of soybean oil per pound during 1955-56, these differences are equivalent to 2.9 to 4.0 cents, respectively, per bushel of soybeans, which brought the farmer an average price of $2.37 that season.

At the three test sites for the 1956-57 season, approximately two-thirds of the estimates, based on the grade factors, ranged within 0.45 to 0.64 percentage point of the laboratory-determined oil content. These percentage points of oil converted to weight per bushel represent differences of 0.27 and 0.38 pounds of oil between the oil estimates and the laboratory-determined oil content. 5/ At the average price of soybean oil per pound during 1956-57, these differences are equivalent to 3.4 to 4.9 cents per bushel of soybeans, which brought the farmer an average price of $2.18 that season. At the average price of oil for the 1957-58 season (10.8 cents) these differences would represent values of 2.9 and 4.1 cents per bushel, which brought the farmer an average price of $2.08.

Since more than one variety of soybeans were included in the study, some of the differences between the estimated and the laboratory oil content probably were due to inherited characteristics of the varieties and not entirely to the grade factors.

3/ Oil content was estimated by the use of multiple regression equations (see table 2).

4/ In 19 times out of 20 at the three test sites for that season, the differences between the estimates and the laboratory-determined oil content were within 0.63, 0.56, and 0.46 pounds of oil and in 99 times out of 100 cases the differences were within 0.85, 0.74, and 0.62 pounds of oil per 60-pound bushel of soybeans.

5/ In 19 times out of 20 at the three test sites for the 1956-57 season, the differences between the oil estimates and the laboratory-determined oil content were within 0.54, 0.56, and 0.78 pounds of oil and in 99 times out of 100 the differences were within 0.73, 0.74, and 1.04 pounds of oil per bushel of soybeans.

Table 2.--Relationship between soybean oil content (expressed as a percentage of total weight) and grade factors, 1/ and accuracy of oil content estimates based on grade factors, by test site, 1955-56 and 1956-57

Marketing year and test site	Carload lots sampled 2/	Coefficient of-- Correlation 3/	Coefficient of-- Determination 4/	Standard error of estimate 5/	Product	Regression equation 6/ Constant	Test weight	Moisture	Foreign material	Splits
	Number	Degree	Percent	Percent		Percent	--Regression coefficients 7/--			
1955-56:										
Ames, Iowa	173	0.425	0.181	0.528	Oil =	29.1948	-0.1758	0.0091	-0.2359	-0.0112
Decatur, Ill.	176	.663	.439	.468	Oil =	35.5003	-.2229	-.2466	-.2753	.0158
Des Moines, Iowa ..	144	.362	.131	.383	Oil =	25.5313	-.0932	-.0500	-.2692	.0415
1956-57:										
Ames, Iowa	124	.764	.584	.449	Oil =	36.9531	-.2408	-.4926	.0464	.0540
Decatur, Ill.	198	.393	.155	.466	Oil =	15.2165	.0885	-.0478	-.1070	-.0134
Des Moines, Iowa ..	125	.422	.178	.642	Oil =	33.1095	-.2322	-.0374	-.1859	-.0245

1/ Damage as a grade factor was omitted due to insufficient data for comparable analysis.

2/ Approximately one-third random sample used in the analysis.

3/ Multiple correlation coefficient measures the degree of relationship when one variable is associated with other variables. Perfect relationship between oil content and the grade factors would be 1.

4/ Coefficient of determination is the square of the coefficient of correlation. It measures the percentage of variation in the dependent variable (oil in this case) when associated with one or more independent variables.

5/ Standard error of estimate is a measure of the variation or scatter about the line of regression. Approximately two-thirds of the oil content estimates made by using the regression equations would come within 0.38 to 0.64 percentage point of the actual oil content, depending on the location and year.

6/ The estimating equation of oil content = constant + regression coefficient x average test weight + regression coefficient x average moisture content + regression coefficient x average foreign material + regression coefficient x average splits, i.e., oil content using Ames, Iowa, location 1955-56 crop year = 29.1948 + (-0.1758 x 56.8) + (0.0091 x 10.8) + (-0.2359 x 1.7) + (-0.0112 x 7.4) = 18.81.

7/ Coefficient of regression measures the number of units change in the dependent variable which is associated with a change of one unit in the independent variable.

Table 3.--Quality and value relationship between soybean oil content and estimates of oil based on grade factors, by test sites, 1955-56 and 1956-57 1/

Marketing year and test site	Carload lots sampled 2/	Coefficient of-- Correlation 3/	Coefficient of-- Determination 4/	Accuracy of estimated oil content		Difference in value of oil per bushel of beans	
	Number	Degree	Percent	Percentage points 5/	Pounds 6/	Cents 7/	Cents 8/
1955-56:							
Ames, Iowa	173	0.425	18.1	±0.528	±0.317	±3.96	±3.99
Decatur, Ill.	176	.663	43.9	.468	.281	3.51	3.54
Des Moines, Iowa	144	.362	13.1	.383	.230	2.88	2.90
1956-57:							
Ames, Iowa	124	.764	58.4	.449	.269	3.42	3.39
Decatur, Ill.	198	.393	15.5	.466	.280	3.56	3.53
Des Moines, Iowa	125	.422	17.8	.642	.385	4.89	4.75

1/ Laboratory-determined oil content expressed as a percentage of whole beans. Damage as a grade factor was omitted due to insufficient data on damage for comparable analysis.

2/ Approximately one-third random sample used in the analysis.

3/ Coefficient of multiple correlation (r) measures the degree of relationship when one variable is associated with two or more other variables. Perfect relationship between the oil content and the grade factors would be 1.

4/ Coefficient of determination (r^2 x 100) measures the percentage of variation in the dependent variable when associated with one or more variables. Thus, at Ames, Iowa (1955-56 marketing year), 18.1 percent of the variation in laboratory-determined oil content was concomitant with variation in the grade factors.

5/ Standard error of estimate is a measure of the variation or scatter about the line of regression. Approximately two-thirds of the oil content estimates made by using the regression equations would come within these percentage points of the corresponding laboratory-determined oil content for the respective test sites.

6/ Pounds of oil per 60-pound bushel.

7/ Oil value based on 12.5 cents per pound for 1955-56 and 12.7 cents per pound for 1956-57 marketing years. Each price represents the average price of soybean oil (crude oil, f.o.b. Midwest mills) for the respective marketing years.

8/ Oil value based on 12.6 cents per pound, the average price of soybean oil (crude oil, f.o.b. Midwest mills) for the two marketing years.

Differences in Average Oil Content, by Soybean Grades

Analysis of all the soybean samples obtained at the three test sites during a period of 2 years, classified by grade, showed that the official grades tended to give some indication of the relative quantities of oil in the beans (table 4). Generally the soybeans in the higher grades were found to have a greater average oil content than the beans in the lower grades. These findings agree with those reported in the study by C. H. Kierstead. 6/ In 4 of 11 cases for the first year, however, the average oil content of a given grade was less than that for the next lower grade, though these differences were small. But in only 1 case out of 12 for the second year was the average oil content for a given grade less than that for the next lower grade.

In addition to the somewhat inconsistent gradations of oil content between successive grades, there was considerable variation in oil content within most soybean grades. The average of the variation of oil content within grades for the three test sites in 1955-56 ranged from 0.32 pound of oil per 60-pound bushel for the Sample grade to 1.9 pounds of oil per bushel for grade No. 2. For the following season (1956-57) the average of the variation of oil content within grades for the same three test sites ranged from 0.36 pound of oil per bushel for the Sample grade to 2.1 pounds of oil per bushel for grade No. 2. These variations in oil content within grades indicate the need for a more precise method of determining differences in oil content if the farmer is to receive payment for his soybeans that is more in line with their actual value.

Thus, the money paid out for soybeans at the elevator during the season may represent the actual value for the total of beans purchased. But the individual farmer selling soybeans with a high oil content may be paid too little money and the farmer who sells beans with a low oil content may be paid too much.

Differences in Soybean Product Value, by Soybean Grades

To determine the relationship between the grades and the value of oil and meal obtained from soybeans of different grades, 493 samples collected at three test sites during the 1955-56 marketing year and 447 samples collected at these sites during the 1956-57 season were analyzed and classified by grade. For each grade the following calculations were made: The range, average, and variation of each grade factor; quantity and quality of oil; quantity of protein; quantity of oil and meal recoverable by the solvent process; processing loss; and the value of the oil and meal. From these data, computations were made to determine the variation in product value by grades as shown in table 5. Grade No. 1 was used as the base and the difference in product value of the other soybean grades was measured from this base.

6/ Kierstead, C. H. Marketing Study of Factors Affecting the Quantity and Value of Products Obtained from Soybeans. U. S. Dept. Agr., Prod. and Mktg. Admin., 35 pp, 1952.

Table 4.--Quality and value relationships between average oil content of soybeans by grades, 1955-56 and 1956-57

Marketing year, test site, and grade	Carlots sampled	Average oil content 1/	Difference in average oil content 2/		Difference in value of oil content	
	Number	Percent	Percentage points	Pounds	Cents 3/	Cents 4/
1955-56:						
Ames, Iowa:						
No. 1	47	21.30	base	base	base	base
No. 2	95	20.95	-0.35	-0.210	-2.62	-2.65
No. 3	20	20.66	-.64	-.384	-4.80	-4.84
No. 4	9	20.11	-1.19	-.714	-8.92	-9.00
S. G.	2	21.20	-.10	-.060	-.75	-.76
Decatur, Ill.:						
No. 1	33	21.92	base	base	base	base
No. 2	104	22.00	+.08	+.048	+.60	+.60
No. 3	26	21.52	-.40	-.240	-3.00	-3.02
No. 4	10	21.00	-.92	-.552	-6.90	-6.96
S. G.	3	21.56	-.36	-.216	-2.70	-2.72
Des Moines, Iowa:						
No. 1	89	22.02	base	base	base	base
No. 2	46	21.65	-.37	-.222	-2.78	-2.80
No. 3	7	21.33	-.69	-.414	-5.18	-5.22
No. 4	2	21.36	-.66	-.396	-4.95	-4.99
S. G.	0	---	---	---	---	---
1956-57:						
Ames, Iowa:						
No. 1	13	19.91	base	base	base	base
No. 2	73	19.69	-.22	-.132	-1.68	-1.66
No. 3	30	19.32	-.59	-.354	-4.50	-4.46
No. 4	6	19.97	+.06	+.036	+.46	+.45
S. G.	2	17.70	-2.21	-1.326	-16.84	-16.71
Decatur, Ill.:						
No. 1	50	21.40	base	base	base	base
No. 2	98	21.22	-.18	-.108	-1.37	-1.36
No. 3	33	20.76	-.64	-.384	-4.88	-4.84
No. 4	16	20.48	-.92	-.552	-7.01	-6.96
S. G.	1	19.94	-1.46	-.876	-11.13	-11.04
Des Moines, Iowa:						
No. 1	25	20.97	base	base	base	base
No. 2	70	20.73	-.24	-.144	-1.83	-1.81
No. 3	17	20.47	-.50	-.300	-3.81	-3.78
No. 4	11	20.36	-.61	-.366	-4.65	-4.61
S. G.	2	19.92	-1.05	-.630	-8.00	-7.94

1/ Laboratory-determined oil content expressed as a percentage of dry matter.
2/ The oil content of No. 1 beans is used as a base and the difference in oil content of other grades is measured from this base. Weight of oil is based on a 60-pound bushel. 3/ Oil value at 12.5 cents per pound for 1955-56 and 12.7 cents for 1956-57, the average prices of soybean oil (crude oil, f.o.b. Midwest mills) for these two marketing years. 4/ Oil value at 12.6 cents per pound, the average price of soybean oil (crude oil, f.o.b. Midwest mills) for the two marketing years.

Table 5.--Quality and value relationships between average oil and meal content of soybeans, by grades, 1955-56 and 1956-57

Marketing year, test site, and grade	Samples tested	Foreign material	Laboratory determined: Oil 1/	Laboratory determined: Moisture	Laboratory determined: Protein 1/	Oil: Content 2/	Oil: Recovered 3/	Oil: Value 4/	Meal: Recovered 5/	Meal: Value 6/	Processing loss	Total product value	Variation in product value by grades 7/
	No.	Pct.	Pct.	Pct.	Pct.	Lb.	Lb.	Dol.	Lb.	Dol.	Lb.	Dol.	Ct.
1955-56													
Ames, Iowa:													
No. 1	47	0.81	21.30	10.52	41.57	11.436	11.077	1.38	47.928	1.26	0.995	2.65	Base
No. 2	95	1.59	20.95	10.45	41.16	11.256	10.898	1.36	47.702	1.25	1.400	2.62	2.9
No. 3	20	2.46	20.66	10.58	41.16	11.085	10.731	1.34	47.247	1.24	2.022	2.58	6.2
No. 4	9	3.89	20.11	10.66	40.66	10.780	10.430	1.30	46.692	1.23	2.878	2.53	11.4
S.G.	2	3.05	21.20	10.80	40.88	11.346	10.998	1.37	46.466	1.22	2.536	2.60	4.9
Decatur, Ill.:													
No. 1	33	1.00	21.92	10.95	41.28	11.712	11.358	1.42	47.202	1.24	1.440	2.66	Base
No. 2	104	1.40	22.00	11.22	40.99	11.719	11.308	1.42	46.766	1.23	1.866	2.65	1.0
No. 3	26	2.65	21.52	11.50	41.00	11.427	11.081	1.39	46.150	1.21	2.769	2.60	6.2
No. 4	10	4.03	21.00	11.28	40.73	11.179	10.836	1.35	45.740	1.20	3.424	2.56	10.4
S.G.	3	2.63	21.56	11.33	40.50	11.470	11.123	1.39	46.227	1.22	2.650	2.61	5.5
Des Moines, Iowa:													
No. 1	89	.85	22.02	10.61	41.96	11.810	11.454	1.43	47.413	1.25	1.133	2.68	Base
No. 2	46	1.60	21.65	10.76	41.29	11.592	11.239	1.40	47.100	1.24	1.661	2.64	3.5
No. 3	7	2.63	21.33	10.56	40.40	11.447	11.096	1.39	46.769	1.23	2.135	2.62	6.2
No. 4	2	3.45	21.36	10.65	40.30	11.451	11.105	1.39	46.199	1.22	2.696	2.60	7.6
S.G.	0	---	---	---	---	---	---	---	---	---	---	---	---
1956-57													
Ames, Iowa:													
No. 1	13	.85	19.91	9.43	42.61	10.819	10.449	1.33	49.354	1.17	.197	2.50	Base
No. 2	73	1.44	19.69	9.00	42.37	10.751	10.381	1.32	49.356	1.17	.263	2.49	.9
No. 3	30	2.38	19.32	9.05	41.89	10.543	10.176	1.29	48.972	1.16	.852	2.45	4.4
No. 4	6	3.87	19.97	7.90	41.12	11.035	10.673	1.36	48.236	1.14	1.091	2.50	+ .1
S.G.	2	8.50	17.70	10.95	39.78	9.457	9.118	1.16	45.193	1.07	5.689	2.23	26.8
Decatur, Ill.:													
No. 1	50	1.00	21.40	9.61	42.49	11.606	11.244	1.43	48.236	1.14	.520	2.57	Base
No. 2	98	1.46	21.22	9.64	42.17	11.505	11.145	1.42	48.045	1.14	.810	2.55	1.7
No. 3	33	2.58	20.76	9.56	41.88	11.265	10.907	1.39	47.678	1.13	1.415	2.52	5.6
No. 4	16	3.90	20.48	10.18	41.38	11.037	10.687	1.36	46.708	1.11	2.605	2.46	10.7
S.G.	1	6.30	19.94	9.10	40.92	10.875	10.529	1.34	46.108	1.09	3.363	2.43	14.1
Des Moines, Iowa:													
No. 1	25	.82	20.97	8.19	42.16	11.552	11.182	1.42	49.378	1.17	+.560	2.59	Base
No. 2	70	1.51	20.73	8.25	41.57	11.412	11.044	1.40	49.062	1.16	+.106	2.57	2.4
No. 3	17	2.58	20.47	8.46	40.87	11.243	10.880	1.38	48.440	1.15	.680	2.53	6.0
No. 4	11	3.97	20.36	8.39	40.35	11.191	10.833	1.38	47.671	1.13	1.496	2.51	8.4
S.G.	2	7.95	19.92	9.15	38.78	10.858	10.520	1.34	45.064	1.07	4.416	2.40	18.6

1/ Oil and protein content are expressed as percentage of dry matter (60-pound bushel basis).
2/ Oil weight calculated on a dry matter basis. Example: (Marketing year 1955-56, Ames, Iowa, grade No. 1) 60 lb. - 6.312 lb. of moisture = 53.688 x 21.30 percent oil = 11.436 lb. of oil content.
3/ Oil content minus 0.75 percent residual oil in meal. Example: (Marketing year 1955-56, Ames, Iowa, grade No. 1) 11.436 lb. of oil - (0.75 percent residual oil x 47.928 lb. of meal) = 11.077 lb. of recovered oil.
4/ Value of oil is based on the average price of soybean oil (crude oil, f.o.b. Midwest mills) at 12.5 and 12.7 cents per pound for the 1955-56 and 1956-57 marketing years, respectively.
5/ Meal recovered includes 0.75 percent oil and 12.0 percent moisture. Meal recovered by solvent process. 60 lb. - 0.486 lb. of foreign material (60 lb. - 0.486) x 10.52 percent moisture = - (+6.261) - 11.436 lb. of oil content = 41.817 ÷ 0.8725 correction factor = 47.928 lb. of meal.
6/ Value of meal is based on the average price of soybean meal (f.o.b. Midwest mills) at 2.63 and 2.37 cents per pound for the 1955-56 and 1956-57 marketing years, respectively.
7/ The product value of No. 1 soybeans is considered as base value and the difference in product value of other grades of soybeans is measured from this base. Value carried to five-place accuracy and then rounded.

Analysis of the soybeans indicated that the official grades provide an approximation of the quantities of oil and meal on which soybean product value is based. There is within each grade, however, variation which often is greater than the average difference between successive grades. Consequently, the product value can vary considerably for soybeans which have met the requirements for a given grade. The results for the soybeans in grade No. 4 and in the Sample grade were somewhat erratic; however, the number of samples in these two grades was too small for ideal comparison.

The present pricing of soybeans in trading is based officially on grade standards included in the Grain Standards of the United States. Although the soybean standards are the best yet devised, they are based on factors applicable to grain and, consequently, do not provide a measure for oil content, which is subject to considerable variation. As a result, the standards applied to soybeans appear to work only for the long-term average for a large number of growers when all grades are taken into consideration.

EVALUATING SOYBEANS BY THE DIELECTRIC METHOD

Considerable interest has been shown in the development of the rapid dielectric method for determining the oil content of individual lots of soybeans at the farm market level. The dielectric method is fairly simple for the ordinary elevator worker to use. Briefly stated, this method 7/ consists of grinding for one-half minute, in the cup of a grinder-extractor, a 100-gram sample of soybeans, calculated on a moisture-free basis. After a spatula has been used to loosen the ground material from the sides and bottom of the cup, there is added 100 milliliters of orthodichlorobenzene previously adjusted to the proper dielectric value. 8/ The mixture of finely ground beans and the added solvent is further ground and extracted for 4 minutes. This liquid is then filtered through a Buchner funnel or a pressure filter fitted with a filter paper.

The resulting filtrate (solvent and extracted oil) is placed in the test cell of the oil tester (which has been allowed to warm up for 15 minutes) and vigorously stirred for about 5 seconds. An electric current is then passed through the filtrate in the test cell. The dielectric value decreases proportionately to the amount of oil present in the solvent. The resulting frequency changes in the electric current are indicated on a meter. Conversion tables are then used to translate the meter readings into the percentage of oil content.

7/ An excellent and comprehensive discussion of the dielectric oil-test equipment and procedure can be found in the following references: (1) Hunt, W. H., Neustadt, M. H., Hart, J. R., and Zeleny, Lawrence. A Rapid Dielectric Method for Determining the Oil Content of Soybeans. Jour. Amer. Oil Chemists' Soc., 29(7): 258-261. 1952. (2) Neustadt, M. H. Rapid Testing of Oilseeds for Oil Quantity and Iodine Number of Oil. U. S. Dept. Agr., Tech. Bul. No. 1171. 1957.

8/ The manufacturer of the oil tester has prepared an adjusted and blended solvent available under the name Steinlite Solvent No. 1.

The resulting oil content is expressed as a percentage of dry matter, since the soybean sample was weighed on a moisture-free basis.

Determinations of Oil Content by the Dielectric Method

To determine the relative reliability of the rapid dielectric method in measuring soybean oil content under local market conditions, the relationship between the oil content by dielectric measurement performed at the three test sites and the corresponding oil content determined at a commercial laboratory was obtained for 493 samples during the 1955-56 marketing year and 447 samples during the 1956-57 season. One electronic tester was used at each of the three test sites for the 2-year period. One test by each method was made on each sample, and the dielectric oil content determinations were graphically plotted against the corresponding oil contents as determined by the commercial laboratory using standard procedure. Figure 1 shows the distribution of these points along the regression or trend line for each test site during the 1955-56 season. The distribution of these points representing similar tests for the following season (1956-57) is shown in figure 2. The regression lines were plotted from the regression equations 9/ used in determining the relative accuracy with which laboratory oil test results can be predicted from the corresponding dielectric oil test results.

Analysis of the 2 sets of oil content determinations for 1955-56 showed that the relationship (coefficient of correlation) between the oil content determinations by the dielectric and standard laboratory methods ranged from 0.726 for Ames to 0.585 for Des Moines. For the 1956-57 season the relationships for these three test sites ranged from 0.744 for Des Moines to 0.496 for Decatur. (Perfect relationship between the two sets of oil-content determinations would be equal to 1.0.) While the correlation values indicate the relationship between the two variables, they do not indicate the amount of difference between them. The average of the oil content determinations by the dielectric method for the three test sites during the 1955-56 season was 21.76 percent of oil, whereas the average of the laboratory oil content determinations was 21.53 percent. Approximately two-thirds of the estimates obtained from the dielectric oil determinations at the three test sites for 1955-56 ranged within 0.40 to 0.50 percentage point of the laboratory oil determinations (table 6). These percentage points of oil converted to weight per 60-pound bushel of soybeans represent differences of 0.24 and 0.30 pound of oil between the two

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9/ For 1955-56 the regression lines for the Ames, Decatur, and Des Moines test sites were plotted from the following regression equations: $y = 8.661 + 0.60384x$; $y = 13.937 + 0.35206x$; $y = 12.470 + 0.41077x$, respectively, where y = laboratory oil content (percentage) and x = dielectric oil content (percentage). For 1956-57 the regression lines were plotted from the following regression equations: For the Ames test site, $y = 6.281 + 0.68098x$; for Decatur, $y = 14.569 + 0.31051x$; and for Des Moines, $y = 6.937 + 0.65454x$.

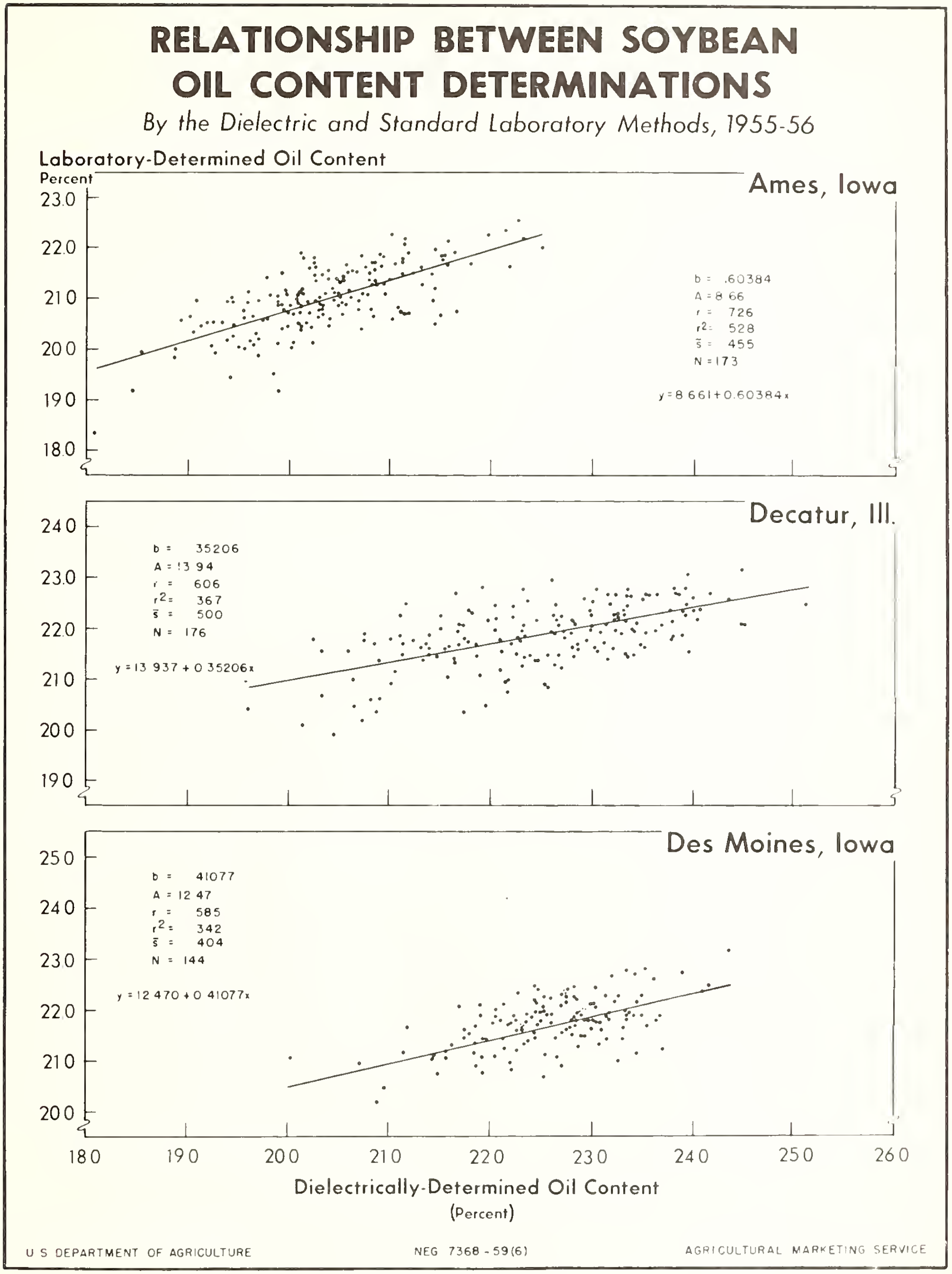
RELATIONSHIP BETWEEN SOYBEAN OIL CONTENT DETERMINATIONS
By the Dielectric and Standard Laboratory Methods, 1955-56
Laboratory-Determined Oil Content
Percent
Ames, Iowa
b = .60384
A = 8 66
r = 726
r2 = 528
s = 455
N = 173
y = 8 661 + 0.60384x
Decatur, Ill.
b = 35206
A = 13 94
r = 606
r2 = 367
s = 500
N = 176
y = 13 937 + 0 35206x
Des Moines, Iowa
b = 41077
A = 12 47
r = 585
r2 = 342
s = 404
N = 144
y = 12 470 + 0 41077x
Dielectrically-Determined Oil Content
(Percent)
U S DEPARTMENT OF AGRICULTURE
NEG 7368 - 59(6)
AGRICULTURAL MARKETING SERVICE

Figure 1

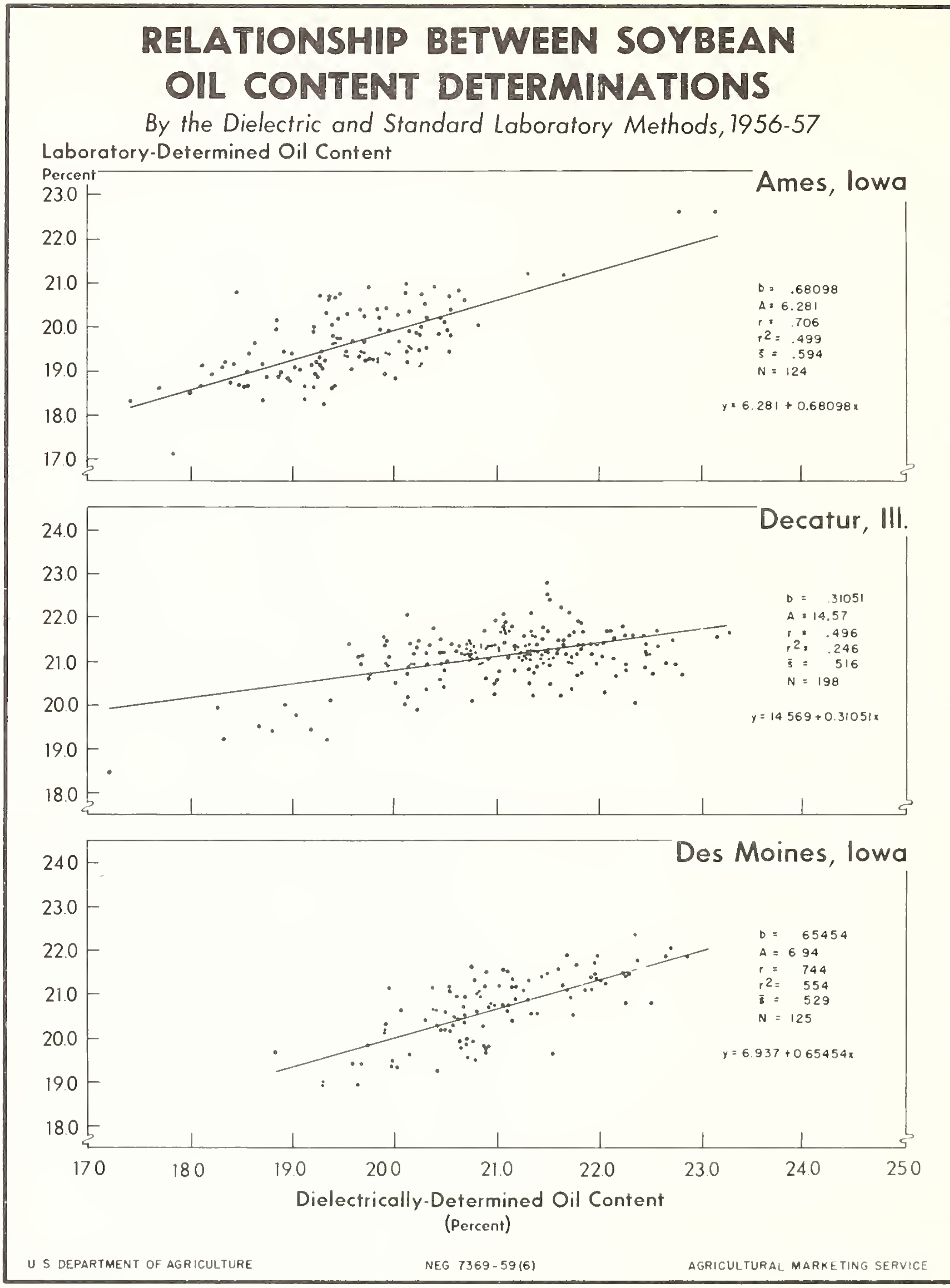
RELATIONSHIP BETWEEN SOYBEAN
OIL CONTENT DETERMINATIONS
By the Dielectric and Standard Laboratory Methods, 1956-57
Laboratory-Determined Oil Content
Percent
Ames, Iowa
b = .68098
A = 6.281
r = .706
r2 = .499
s = .594
N = 124
y = 6.281 + 0.68098x
Decatur, Ill.
b = .31051
A = 14.57
r = .496
r2 = .246
s = 516
N = 198
y = 14 569 + 0.31051x
Des Moines, Iowa
b = 65454
A = 6 94
r = 744
r2 = 554
s = 529
N = 125
y = 6.937 + 0 65454x
Dielectrically-Determined Oil Content
(Percent)
U S DEPARTMENT OF AGRICULTURE
NEG 7369-59(6)
AGRICULTURAL MARKETING SERVICE

Figure 2

Table 6.--Quantity and value relationship between soybean oil content determined by the dielectric and standard laboratory methods, by test sites, 1955-56 and 1956-57 1/

Marketing year and test site	Oil tests	Coefficient of-- Correlation 2/	Coefficient of-- Determination 3/	Accuracy of estimated oil content		Difference in value of oil per bushel of beans	
	Number	Degree	Percent	Percentage points 4/	Pounds 5/	Cents 6/	Cents 7/
1955-56:							
Ames, Iowa	173	0.726	52.8	±0.455	±0.273	±3.41	±3.44
Decatur, Ill.	176	.606	36.7	±.500	±.301	±3.76	±3.79
Des Moines, Iowa..	144	.585	34.2	±.404	±.242	±3.02	±3.05
1956-57:							
Ames, Iowa	124	.706	49.9	±.594	±.356	±4.52	±4.48
Decatur, Ill.	198	.496	24.6	±.516	±.310	±3.94	±3.91
Des Moines, Iowa..	125	.744	55.4	±.529	±.317	±4.02	±3.99

1/ Oil content expressed as a percentage of dry matter.

2/ Coefficient of correlation (r) measures the degree of relationship when one variable is associated with another. Perfect relationship between the oil content results obtained by the two methods would be 1.

3/ Coefficient of determination (r^2 x 100) measures the percentage of variation in the dependent variable when associated with one or more independent variables. Thus, at Ames, Iowa, 1955-56, 52.8 percent of the variation in the laboratory-determined oil content is concomitant with variation in the dielectrically determined oil content.

4/ Standard error of estimate is a measure of the variation or scatter about the line of regression. Approximately two-thirds of the estimates made by converting dielectric oil content determinations by the regression equations would come within these percentage points of the corresponding oil determinations obtained by the commercial laboratory, depending on the dielectric oil tester used.

5/ Pounds of oil per 60-pound bushel.

6/ Oil value based on 12.5 cents per pound for 1955-56 and 12.7 cents per pound for 1956-57 marketing years. Each price represents the average price of soybean oil (crude oil, f.o.b. Midwest mills) for the respective marketing years.

7/ Oil value based on 12.6 cents per pound, the average price of soybean oil (crude oil, f.o.b. Midwest mills) for the two marketing years.

methods. 10/ At the average price of soybean oil for the 1955-56 marketing year, these would be equal to 3.0 and 3.8 cents per bushel of soybeans which brought the farmer an average price of $2.37 that season.

At the three test sites for the 1956-57 season, approximately two-thirds of the estimates based on the dielectric oil determinations ranged within 0.52 to 0.59 percentage point of the laboratory oil determinations. These percentage points of oil converted to weight per bushel of soybeans represent differences of 0.31 and 0.36 pound of oil between the two methods. 11/ At the average price of soybean oil for the 1956-57 marketing year, these would be equal to 3.9 and 4.5 cents per bushel of soybeans which brought the farmer an average price of $2.18 that season. At the average price of this oil for the 1957-58 season (10.8 cents per pound) these differences in pounds of oil would represent values of 3.3 and 3.9 cents per bushel of soybeans which brought the farmer an average price of $2.08.

For all three test sites the differences between the estimates obtained from the dielectric oil determinations and the laboratory oil test results were similar to the differences between the estimates of oil content from soybean grade factors and the laboratory oil test results. Moreover, the dielectric method provided the percentage of oil content, not provided in the present method of estimating the market value of soybeans from the official grade factors. Furthermore, estimating oil content from soybean grade factors, which requires rather complex and time-consuming statistical procedures, would not be practical for trading purposes.

Differences Between Oil Content as Determined by the Dielectric and Standard Laboratory Methods, by Soybean Grades

The difference between oil content of soybeans as determined by the dielectric and standard methods was computed for each grade to determine whether there was any relationship between the grades and the amount of difference in average oil content as determined by the two methods. The analysis indicated that for the higher grades there tended to be a little more agreement between the oil content results by the two methods than for the lower grades, though there were exceptions. For instance, in 7 of 11 cases for the 1955-56 season and in 10 of 12 cases for the 1956-57 season, there was slightly less difference between the average oil determinations by the two methods for a given grade of soybeans than for the next lower grade (table 7), though, as mentioned earlier, the number of observations for the No. 4 and Sample grades was too small for conclusive results.

10/ In 19 times out of 20 at the three test sites, the differences between the oil content determined by the two methods were within 0.54, 0.59, and 0.48 pounds of oil, respectively, and in 99 times out of 100 the oil differences were within 0.71, 0.78, and 0.63 pounds of oil per 60-pound bushel.

11/ In 19 times out of 20 at the three test sites, the differences between the oil content determined by the two methods were within 0.71, 0.61, and 0.62 pounds of oil, respectively, and in 99 times out of 100 the oil differences were within 0.93, 0.81, and 0.83 pounds of oil per bushel.

Table 7.--Quality and value relationships between soybean oil content, determined by the dielectric and standard laboratory methods, by soybean grades, 1955-56 and 1956-57

Marketing year, test site, and grade	Samples tested	Average: Laboratory oil 1/	Average: Dielectric oil 1/	Difference in average oil content				Average deviation 4/	Relative variation of difference 5/
	No.	Pct.	Pct.	Pct.	Lb.	Ct. 2/	Ct. 3/	Pct.	Pct.
1955-56									
Ames, Iowa:									
No. 1	47	21.30	20.57	-0.73	-0.438	-5.48	-5.52	0.46	64
No. 2	95	20.95	20.39	-.56	-.337	-4.21	-4.25	.57	102
No. 3	20	20.66	20.22	-.44	-.263	-3.29	-3.31	.51	115
No. 4	9	20.11	19.75	-.36	-.219	-2.74	-2.76	.78	217
S.G.	2	21.20	20.56	-.64	-.387	-4.84	-4.88	.36	56
Decatur, Ill.:									
No. 1	33	21.92	22.46	.54	.322	4.02	4.06	.96	178
No. 2	104	22.00	22.65	.65	.388	4.85	4.89	.84	130
No. 3	26	21.52	22.21	.69	.414	5.18	5.22	.95	137
No. 4	10	21.00	21.47	.47	.283	3.54	3.57	.55	117
S.G.	3	21.56	22.46	.90	.538	6.72	6.78	.67	74
Des Moines, Iowa:									
No. 1	89	22.02	22.79	.77	.460	5.75	5.80	.58	76
No. 2	46	21.65	22.56	.91	.544	6.80	6.85	.52	58
No. 3	7	21.33	22.26	.93	.555	6.94	6.99	.66	71
No. 4	2	21.36	23.18	1.82	1.089	13.61	13.72	.91	50
S.G.	0	---	---	---	---	---	---	---	---
1956-57									
Ames, Iowa:									
No. 1	13	19.91	19.96	.05	.033	.42	.42	.57	1,138
No. 2	73	19.69	19.58	-.11	-.068	-.86	-.86	.65	587
No. 3	30	19.32	19.44	.12	.071	.90	.89	.67	556
No. 4	6	19.97	19.68	-.29	-.174	-2.21	-2.19	.87	301
S.G.	2	17.70	18.27	.57	.342	4.34	4.31	.23	40
Decatur, Ill.:									
No. 1	50	21.40	21.27	-.13	-.080	-1.02	-1.01	.63	483
No. 2	98	21.22	21.08	-.14	-.081	-1.03	-1.02	.83	592
No. 3	33	20.76	20.96	.20	.118	1.50	1.49	.88	438
No. 4	16	20.48	20.98	.50	.298	3.78	3.75	1.06	212
S.G.	1	19.94	18.27	-1.67	-1.002	-12.73	-12.63	---	---
Des Moines, Iowa:									
No. 1	25	20.97	21.09	.12	.069	.88	.87	.68	565
No. 2	70	20.73	21.08	.35	.208	2.64	2.62	.60	171
No. 3	17	20.47	21.17	.70	.419	5.32	5.28	.59	85
No. 4	11	20.36	21.00	.64	.383	4.86	4.83	.57	89
S.G.	2	19.92	20.28	.36	.216	2.74	2.72	.38	106

1/ Oil expressed as a percentage of dry matter (60-pound bushel basis).
2/ Oil value at 12.5 cents per pound for 1955-56 and 12.7 cents for 1956-57, the average prices of soybean oil (crude, f.o.b. Midwest mills) for these two marketing years.
3/ Oil value at 12.6 cents per pound, the average price of soybean oil (crude oil, f.o.b. Midwest mills) for the two marketing years.
4/ Standard deviation of the difference between the average oil determinations by the two methods. It is a special form of average deviation from the mean or the root-mean-square of the deviations from the arithmetic mean.
5/ Coefficient of variation is a relative measure of dispersion. It equals the standard deviation of a variable expressed as a percentage of its average. Its advantage here lies in the fact that it provides a measure of dispersion for comparison to the size of the average about which it is measured.

Differences in Soybean Product Value Based on Dielectric Oil Content Analysis, by Soybean Grades

Relationships between the soybean grades and the value of oil and meal obtained from soybeans of different grades were discussed earlier in this report. To provide a basis for direct comparison with those findings, the differences in soybean product values based on dielectric oil content analysis also were computed by soybean grades. For each grade, calculations were made for the quality and quantity of oil, quantity of protein, quantity of oil and meal recoverable by the solvent process, processing loss, and value of the oil and meal. From these data, computations were made for the same samples to determine the variation in product values based on dielectric oil content analysis, by soybean grades, as shown in table 8. Grade No. 1 was used as the base and the differences in values of the other soybean grades were measured from this base.

Analysis of the soybeans indicated that for both marketing years (1955-56 and 1956-57) the differences in product values between soybean grades at all three test sites generally were somewhat smaller when based on the dielectric oil content analysis than when based on laboratory oil determinations. For example, the average difference in soybean product value between grade No. 1 and grade No. 2, when based on the dielectric oil content determinations for the two marketing seasons, was 1.7 and 1.5 cents, respectively, per bushel of soybeans, whereas the average difference based on the laboratory oil determinations for the two seasons was 2.5 and 1.7 cents, respectively. Moreover, the average difference in product value between the No. 1 and No. 3 grades, when based on dielectric oil analysis for the 1955-56 season, was 5.2 cents and for 1956-57 it was 3.5 cents per bushel. The corresponding average differences based on laboratory oil determinations for the two seasons were 6.2 and 5.3 cents, respectively.

SOURCES OF VARIATION IN THE DIELECTRIC OIL CONTENT DETERMINATIONS

Several factors can influence the oil content determination by the dielectric method. These include: Accuracy of weighing the samples, sharpness of the cutter blade used in grinding samples, accuracy in measuring the solvent, temperature of the test cell and of the solvent in the test cell, accuracy of moisture content readings for soybean samples, and adjustment and balance of the oil tester.

Variation in Oil Content Determinations During 1955-56

In the 493 comparative tests run during the 1955-56 season, the dielectric oil determinations averaged 0.26 percentage point higher than the corresponding oil determinations from the laboratory. The dielectric oil test results, however, were not all uniformly higher. The dielectric oil test run at Ames, Iowa, averaged 0.58 percentage point of oil lower than the corresponding laboratory tests. At Decatur, Ill., and Des Moines, Iowa, the dielectric

Table 8.--Quality and value relationships between average oil and meal content of soybeans, based on dielectric oil determinations, by soybean grades, 1955-56 and 1956-57

Marketing year, test site and grade	Samples tested	Foreign material	Dielectric oil 1/	Laboratory determined: Moisture	Laboratory determined: Protein 1/	Oil: Content 2/	Oil: Recovered 3/	Oil: Value 4/	Meal: Recovered 5/	Meal: Value 6/	Processing loss	Total product value	Variation in product value by grade 7/
	No.	Pct.	Pct.	Pct.	Pct.	Lb.	Lb.	Dol.	Lb.	Dol.	Lb.	Dol.	Ct.
1955-56													
Ames, Iowa:													
No. 1	47	0.81	20.57	10.52	41.57	11.044	10.681	1.34	48.377	1.27	0.942	2.61	Base
No. 2	95	1.59	20.39	10.45	41.16	10.956	10.596	1.32	48.046	1.26	1.358	2.59	1.9
No. 3	20	2.46	20.22	10.58	41.16	10.848	10.491	1.31	47.546	1.25	1.963	2.56	4.6
No. 4	9	3.89	19.75	10.66	40.66	10.587	10.235	1.28	46.913	1.23	2.852	2.51	9.4
S.G.	2	3.05	20.56	10.80	40.88	11.004	10.653	1.33	46.858	1.23	2.489	2.56	4.3
Decatur, Ill.:													
No. 1	33	1.00	22.46	10.95	41.28	12.000	11.648	1.46	46.872	1.23	1.480	2.69	Base
No. 2	104	1.40	22.65	11.22	40.99	12.065	11.717	1.46	46.369	1.22	1.914	2.68	.4
No. 3	26	2.65	22.21	11.50	41.00	11.794	11.451	1.43	45.730	1.20	2.819	2.63	5.5
No. 4	10	4.03	21.47	11.28	40.73	11.429	11.086	1.39	45.453	1.20	3.459	2.58	10.8
S.G.	3	2.63	22.46	11.33	40.50	11.949	11.606	1.45	45.678	1.20	2.716	2.65	3.7
Des Moines, Iowa:													
No. 1	89	.85	22.79	10.61	41.96	12.223	11.871	1.48	46.940	1.23	1.189	2.72	Base
No. 2	46	1.60	22.56	10.76	41.29	12.080	11.731	1.47	46.541	1.22	1.728	2.69	2.9
No. 3	7	2.63	22.26	10.56	40.40	11.946	11.600	1.45	46.197	1.21	2.203	2.66	5.4
No. 4	2	3.45	23.18	10.65	40.30	12.427	12.069	1.51	45.081	1.19	2.830	2.70	2.2
S.G.	0	--	--	--	--	--	--	--	--	--	--	--	--
1956-57													
Ames, Iowa:													
No. 1	13	.85	19.96	9.43	42.61	10.847	10.477	1.33	49.321	1.17	.202	2.50	Base
No. 2	73	1.44	19.58	9.00	42.37	10.691	10.320	1.31	49.425	1.17	.255	2.48	1.8
No. 3	30	2.38	19.44	9.05	41.89	10.608	10.241	1.30	48.897	1.16	.862	2.46	4.0
No. 4	6	3.87	19.68	7.90	41.12	10.875	10.512	1.34	48.419	1.15	1.069	2.48	1.7
S.G.	2	8.50	18.27	10.95	39.78	9.762	9.426	1.20	44.844	1.06	5.730	2.26	24.0
Decatur, Ill.:													
No. 1	50	1.00	21.27	9.61	42.49	11.536	11.174	1.42	48.316	1.15	.510	2.56	Base
No. 2	98	1.46	21.08	9.64	42.17	11.429	11.068	1.41	48.132	1.14	.800	2.55	1.7
No. 3	33	2.58	20.96	9.56	41.88	11.374	11.017	1.40	47.553	1.13	1.430	2.53	3.8
No. 4	16	3.90	20.98	10.18	41.38	11.307	10.959	1.39	46.399	1.10	2.642	2.49	7.2
S.G.	1	6.30	18.27	9.10	40.92	9.964	9.610	1.22	47.152	1.12	3.238	2.34	22.6
Des Moines, Iowa:													
No. 1	25	.82	21.09	8.19	42.16	11.618	11.248	1.43	49.302	1.17	+.550	2.60	Base
No. 2	70	1.51	21.08	8.25	41.57	11.605	11.239	1.43	48.841	1.16	+.080	2.59	1.1
No. 3	17	2.58	21.17	8.46	40.87	11.627	11.267	1.43	48.000	1.14	.733	2.57	2.7
No. 4	11	3.97	21.00	8.39	40.35	11.543	11.188	1.42	47.268	1.12	1.544	2.54	5.5
S.G.	2	7.95	20.28	9.15	38.78	11.055	10.719	1.36	44.838	1.06	4.443	2.42	17.2

1/ Oil and protein content are expressed as percentage of dry matter (60-pound bushel basis).

2/ Oil weight calculated on a dry matter basis. Example: (Marketing year, 1955-56, Ames, Iowa, grade No. 1) 60 lb. - 6.312 lb. of moisture = 53.688 x 20.57 percent oil = 11.044 lb. of oil content.

3/ Oil content minus 0.75 percent residual oil in meal. Example: (Marketing year, 1955-56, Ames, Iowa, grade No. 1) 11.044 lb. of oil - (0.75 percent residual oil x 48.377 lb. of meal) = 10.681 lb. of recovered oil.

4/ Value of oil is based on the average price of soybean oil (crude oil, f.o.b. Midwest mills) at 12.5 and 12.7 cents per pound for the 1955-56 and 1956-57 marketing years, respectively.

5/ Meal recovered includes 0.75 percent oil and 12.0 percent moisture. Example: (Marketing year, 1955-56, Ames, Iowa, grade No. 1) Meal recovered by solvent process. 60 lb. - 0.486 lb. of foreign material (60 lb. - 0.486) x 10.52 percent moisture = - (+6.261) - 11.044 lb. of oil content = 42.209 ÷ 0.8725 correction factor = 48.377 lb. of meal.

6/ Value of meal is based on the average price of soybean meal (f.o.b. Midwest mills) at 2.63 and 2.37 cents per pound for the 1955-56 and 1956-57 marketing years, respectively.

7/ The product value of No. 1 soybeans is considered as base value and the difference in product value of other grades of soybeans is measured from this base. Value carried to five-place accuracy and then rounded.

oil tests averaged 0.63 and 0.83 percentage points of oil, respectively, higher than the corresponding laboratory oil tests. In figure 3, the laboratory test results for the three test sites are presented as a constant, or standard, while the average differences of the dielectric test results are shown by months to indicate trends of variation from the standard for the 1955-56 season.

Analysis 12/ of the combined data for all three test sites during that period indicated that 45.1 percent of the variation in differences between the dielectric and the laboratory oil determinations was due to variation among the three test sites. This variation among the test sites could have resulted from adjustments of the three dielectric oil testers, possible differences in average temperature of the test cells and solvent, and degree of attention given to details of testing procedure at the three locations.

Changing a cutter blade (after grinding 112 samples) for a new cutter blade on the grinding mill at the Decatur test site accounted for 0.8 percent of the variation in the oil content determined by the two methods. The cutter blades for the grinder mills at Ames and Des Moines were not changed during the season.

A tendency for the dielectric oil determinations to drift downward at the Ames test site and upward at the Des Moines site accounted for 22.6 percent of the variation. These drifts suggest the possibility of a gradual change in the electronic balance of the oil testers together with a difference in the relative dulling of the cutter blades used in grinding the samples.

At the Ames and Des Moines test sites there was a tendency for the first sample on each testing day to show significantly lower oil content than the remaining samples tested in series. This accounted for 1.1 percent of the difference. This could have been due to insufficient warming up of the test cell or to improper cleaning of the test cell, allowing a residual film of oil to remain on the cell wall surfaces from one testing day to the next.

About 70 percent of the total variation in the differences between the oil content obtained by the dielectric and standard laboratory methods for that year was due to these four sources of variation, leaving about 30 percent of the variation unexplained. After these four sources of variation were statistically removed, in two out of three cases the difference between the oil content determined by the dielectric and the standard methods was within 0.516 in terms of percentage of oil or 0.31 pound of oil per 60-pound bushel. In 99 times out of 100 this difference would be within 1.33 percentage point or 0.80 pound of oil.

Variation in Oil Content Determinations During 1956-57

For the 447 comparative tests run during the 1956-57 season, the dielectric oil determinations averaged only 0.08 percentage point higher than the

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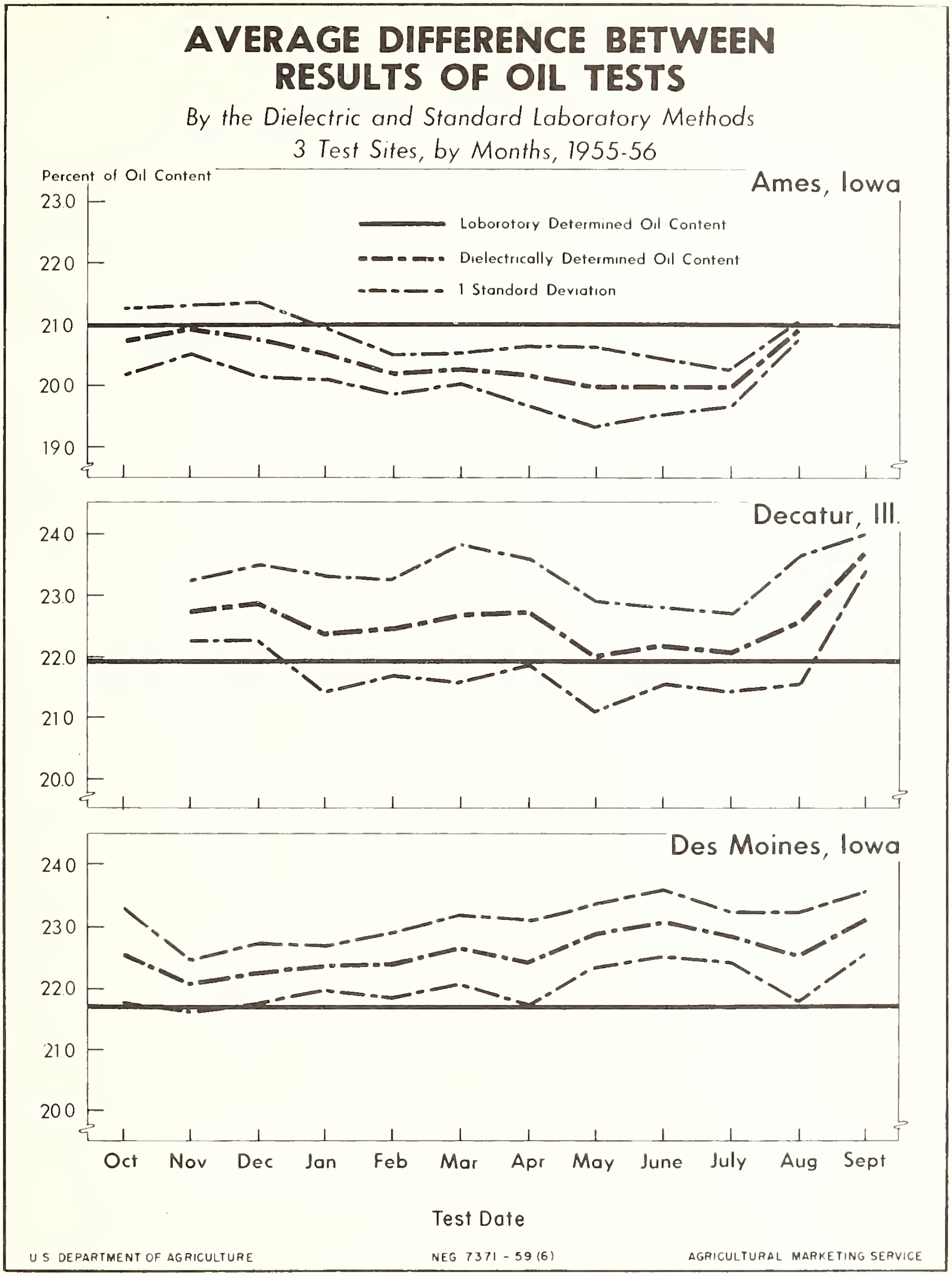
12/ Analysis of variance method was used.


AVERAGE DIFFERENCE BETWEEN
RESULTS OF OIL TESTS
By the Dielectric and Standard Laboratory Methods
3 Test Sites, by Months, 1955-56
Percent of Oil Content
Ames, Iowa
Loborotory Determined Oil Content
Dielectrically Determined Oil Content
1 Standord Deviation
23.0
22.0
21.0
20.0
19.0
Decatur, Ill.
24.0
23.0
22.0
21.0
20.0
Des Moines, Iowa
24.0
23.0
22.0
21.0
20.0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
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Test Date
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Figure 3

corresponding oil determinations from the laboratory. The average difference between the test results by the two methods for the three test sites was small, in part because the dielectric oil determinations that were higher than the laboratory determinations just about compensated for those that were lower. The dielectric oil tests run at Des Moines averaged 0.37 percentage point of oil higher than the corresponding laboratory oil tests. However, at Ames and Decatur, the dielectric oil tests averaged 0.04 percentage point lower than the corresponding laboratory oil tests. In figure 4 the laboratory test results are presented as a constant, or standard, while the average differences of the dielectric test results are shown by months to indicate trends of variation from the standard for the 1956-57 season.

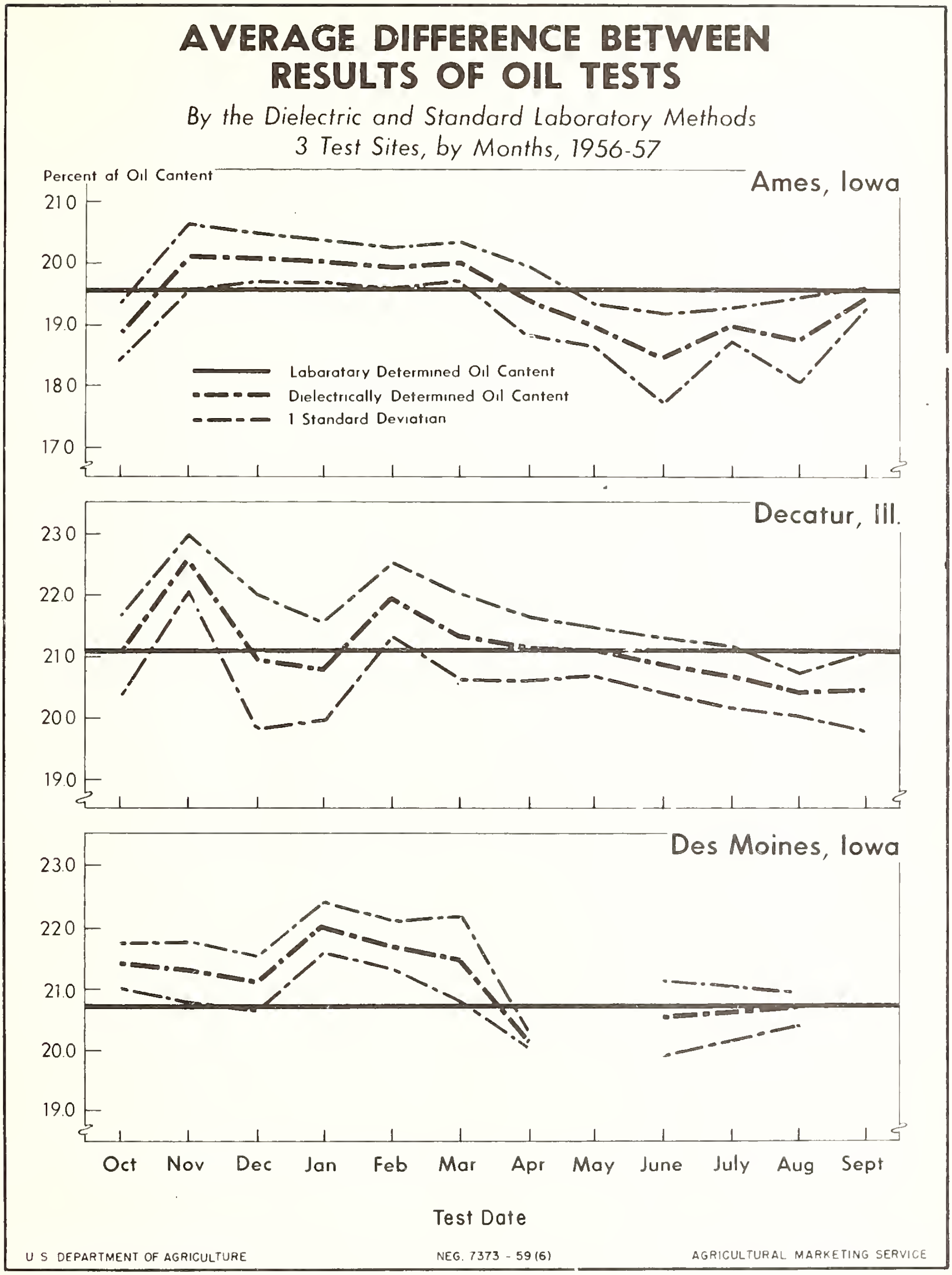
For that season, analysis of the data for the three test sites indicated that 21.8 percent of the variation between the dielectric and laboratory oil determinations was due to variation among the test sites.

Replacing the regular steel cutter blades with new high-carbon steel cutter blades on the grinding mills (after grinding 20 samples at Ames, 39 at Decatur, and 60 at Des Moines that season) accounted for 2.7 percent of the variation in the oil content determined by the two methods. After installation of these new cutter blades, the dielectric oil test results at all three test sites increased above those determined at the laboratory. These oil test results for Decatur, however, were more erratic than those for the other two test sites. The increase in the dielectrically determined oil content apparently resulted from improvement in the grinding of the soybean samples.

Despite the increase in the dielectric oil determinations after installation of the new-type cutter blades, there was a tendency for these oil determinations to drift downward at Ames and Decatur. These drifts accounted for 36.4 percent of the variation for the season. Since high-carbon steel cutter blades are more resistant to dulling from use than the conventional-type steel blades, there is a strong indication that most of the downward drift resulted from a gradual change in the electronic balance of the oil testers. This explanation is further suggested by the fact that there was significant improvement in the dielectric oil test results at Des Moines after a downward adjustment of the oil tester, which had been indicating oil content results that were too high compared with those obtained by the laboratory.

At all three test sites there was a tendency for the first sample on each testing day to show significantly different oil content than the remaining samples tested in series. This accounted for 2.6 percent of the variation. At Ames, three out of five samples, and at Des Moines, five out of six of the samples that were run first tested lower in oil content, whereas at Decatur, two-thirds of the samples run first tested higher than the succeeding samples in series.

Approximately 64 percent of the total variation between the oil content obtained by the dielectric and standard laboratory methods during the season was due to the sources of variation mentioned, leaving about 36 percent of the variation unexplained. After these sources of variation were statistically


AVERAGE DIFFERENCE BETWEEN RESULTS OF OIL TESTS
By the Dielectric and Standard Laboratory Methods
3 Test Sites, by Months, 1956-57
Percent of Oil Content
Ames, Iowa
21.0
20.0
19.0
18.0
17.0
Laboratory Determined Oil Content
Dielectrically Determined Oil Content
1 Standard Deviation
Decatur, Ill.
23.0
22.0
21.0
20.0
19.0
Des Moines, Iowa
23.0
22.0
21.0
20.0
19.0
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Test Date
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Figure 4

removed, in two out of three cases the difference between the oil content determined by the two methods was within 0.467 in terms of percentage of oil or 0.28 pound of oil per 60-pound bushel of soybeans. In 99 times out of 100 this difference would be within 1.21 percentage points or 0.73 pound of oil per bushel.

VARIATION IN SOYBEAN OIL TEST RESULTS AMONG COMMERCIAL LABORATORIES

During World War II the official method of the American Oil Chemists' Society (Ac 3-44) 13/ was used to determine soybean oil content, as supplemental to the Official Grain Standards, to provide a basis for trading between processors and the Commodity Credit Corporation. This method 14/, which had not been used previously in connection with large-scale commercial trading, was found to be practical on the basis of freight carlots or equivalent loads received at terminal elevators. Often soybean samples from as many as five freight cars were combined into one composite sample for oil testing to facilitate trading on an oil-content basis.

After application of oil analysis as an adjunct to the use of official grade standards for soybean trading in 1941, there were some complaints and criticisms by processors concerning inconsistencies in the oil test results. To overcome these inconsistencies, laboratory equipment requirements and the instructions on analysis procedures were amended and made more exacting. Also, an educational campaign was conducted concerning the proper use of the equipment and the method, and a close check was made on the performance of certified chemists. These measures led to such improvements in the reproducibility and concordance of results among different laboratories that within three years the settlements based on oil content were handled smoothly and satisfactorily. These results, however, were brought about by a great amount of effort compared with that required in the regular grading practice for soybeans. 15/

13/ Mehlenbacker, V. C., and Hopper, T. H. (editors), Official and Tentative Methods of the American Oil Chemists' Society. Second ed., Revised. 1955.

14/ Briefly stated, the method consists of drying a 60-gram sample of soybeans for 2 hours at 130° C., and then grinding to a near-flour in a high-speed attrition mill. After this ground material is thoroughly mixed, a 2-gram sample is taken from the larger sample and extracted with petroleum ether for 2 hours, after which the ether is evaporated from the material, which is again thoroughly ground in a mortar with a pestle for 1 minute (or with 100 vigorous strokes), and then the extraction with petroleum ether is continued for an additional 3 hours. The moisture content of the sample also is determined so that the oil test results are calculated on a dry basis or to a predetermined moisture content.

15/ Doughtie, R. T., Jr. Sampling of Cottonseed, Soybeans, and Peanuts: Methods Used and Problems Encountered. Jour. Amer. Oil Chemists' Soc., 24 (10): 335-340. 1947.

Despite the care with which the official method is followed, some variation in oil content determinations for a given sample of soybeans can be expected even when made by Government-approved chemists. A study 16/ comparing soybean oil content determinations obtained by 23 approved chemists for 50 or more soybean check samples indicated that, for 57 percent of the oil determinations, the variation was within 0.20 percentage point of the oil content determinations by referee chemists. Fifteen percent of the oil determinations varied between 0.20 and 0.30 percentage points from the corresponding test results obtained by the referee chemists. The variation for the remaining 28 percent of the oil determinations was somewhat greater than 0.30 percentage point.

The Smalley Foundation Committee (subcommittee on oilseeds) of the American Oil Chemists' Society conducts an annual check soybean series in which chemists of commercial laboratories and those of some other private firms participate. The committee sends to the chemists of participating firms check samples of soybeans for an analysis to determine the moisture and oil content. These analysis results are then submitted to the committee for comparison and appraisal. This procedure permits the committee to keep a close check on the performance of participating chemists and, where necessary, to insist on improvement of the test results if the chemists are to maintain approved status.

The oil determinations by approved chemists, while generally acceptable to the trade, are subject to some variation, as indicated in figure 5. This figure shows the results obtained on soybean check samples, received from the chemists, of the 11 commercial laboratories which participated in the Check Soybean Series during each of the 12 seasons 1946-47 through 1957-58. The results shown represent oil content determinations for 120 check samples (10 samples per season) received from each of the laboratories during the 12 seasons. About 92 percent of the test results from chemist "A" and about 68 percent from chemist "K" were within 0.20 percentage point of the average of the corresponding oil content determinations submitted by all approved chemists participating for the 12-year period. Variation in oil tests up to 0.20 percentage point from the average corresponding determined standard is within the tolerance accepted by the committee. Of the oil tests run by chemist "A", 5.8 percent exceeded the allowable tolerance by as much as 0.1 percentage point of oil and 2.5 percent exceeded it by as much as 0.2 percentage point, whereas, of the tests run by chemist "K," 13.6 percent exceeded the tolerance by as much as 0.1 percentage point of oil, 8.2 percent by as much as 0.2 percentage point, and 10.0 percent by as much as 0.3 percentage point or more.

Figure 6 indicates the performance of approved chemists of commercial laboratories as a group for each of the 12 seasons 1946-47 through 1957-58. The results shown are for 19 approved chemists who submitted oil content

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16/ Doughtie, R. T., Jr. Comparison of Performances of Approved Chemists Handling Commodity Credit Corporation-Processor Soybean Analysis Work During the Seasons of 1944-45 and 1945-46. Jour. Amer. Oil Chemists' Soc. 24(8): 265-269. 1947.

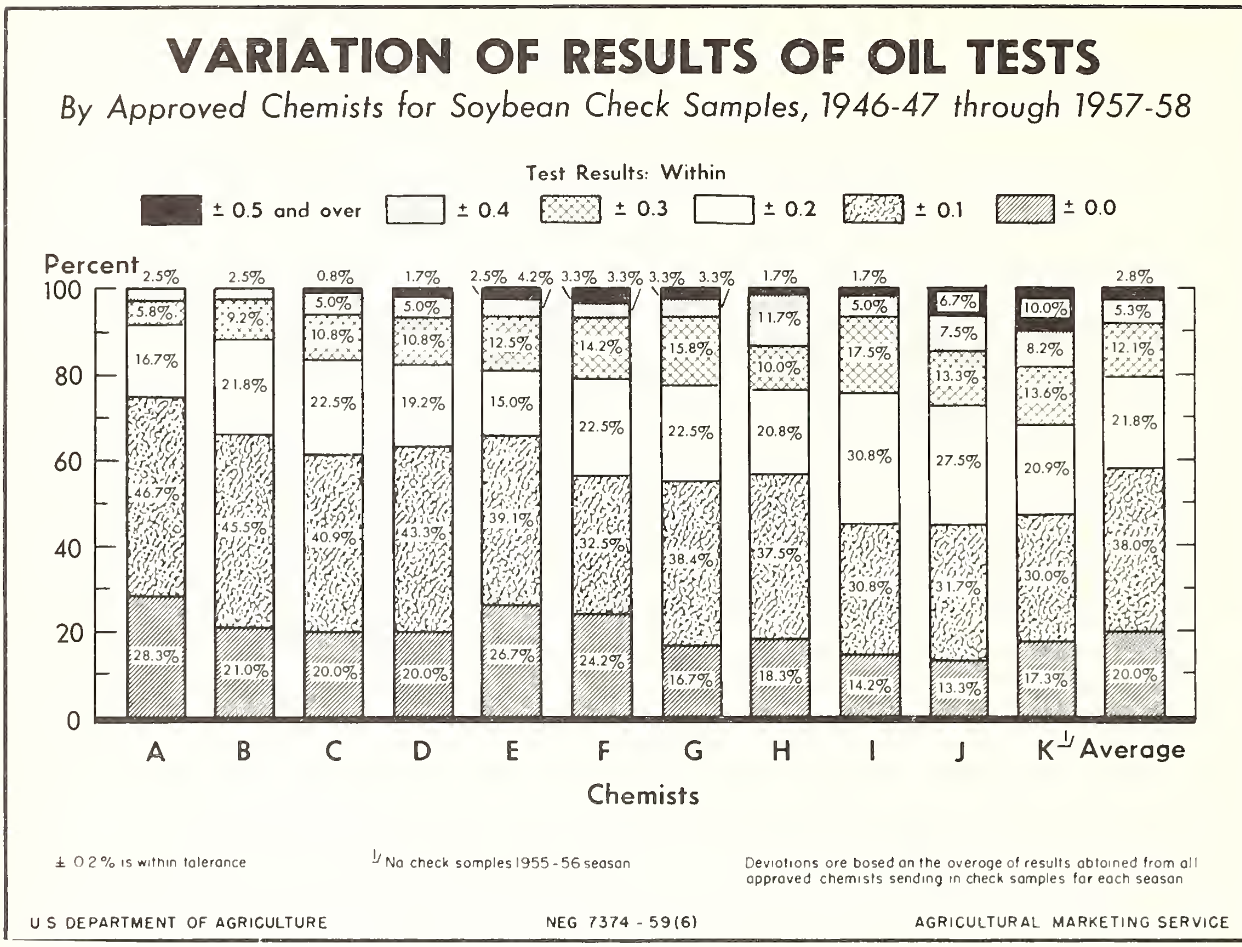

Figure 5

determinations for 7 or more soybean check samples during each of the 12 seasons. Of the oil determinations submitted during the 12 seasons, an average of 77.7 percent were within 0.2 percentage point of the corresponding average standard as determined by the committee (and considered within the acceptable tolerance); 11.7 percent were within 0.3 percentage point; 5.8 percent were within 0.4 percentage point; and 4.8 percent varied as much as 0.5 percentage point or more from the accepted standard oil content.

The variation of oil content determinations among commercial laboratories for soybean check samples, by season, for the seasons 1946-47 through 1957-58, is shown in table 9. The least variation in oil test results among the commercial laboratories was found for the 1954-55 season. For that season, in approximately two-thirds of the cases, the average variation was within 0.185 percentage point of oil of the accepted standard. The greatest variation in oil content determinations among the laboratories occurred during 1953-54. In about two-thirds of the cases for that season, the variation was within 0.330 in terms of percentage of oil content.

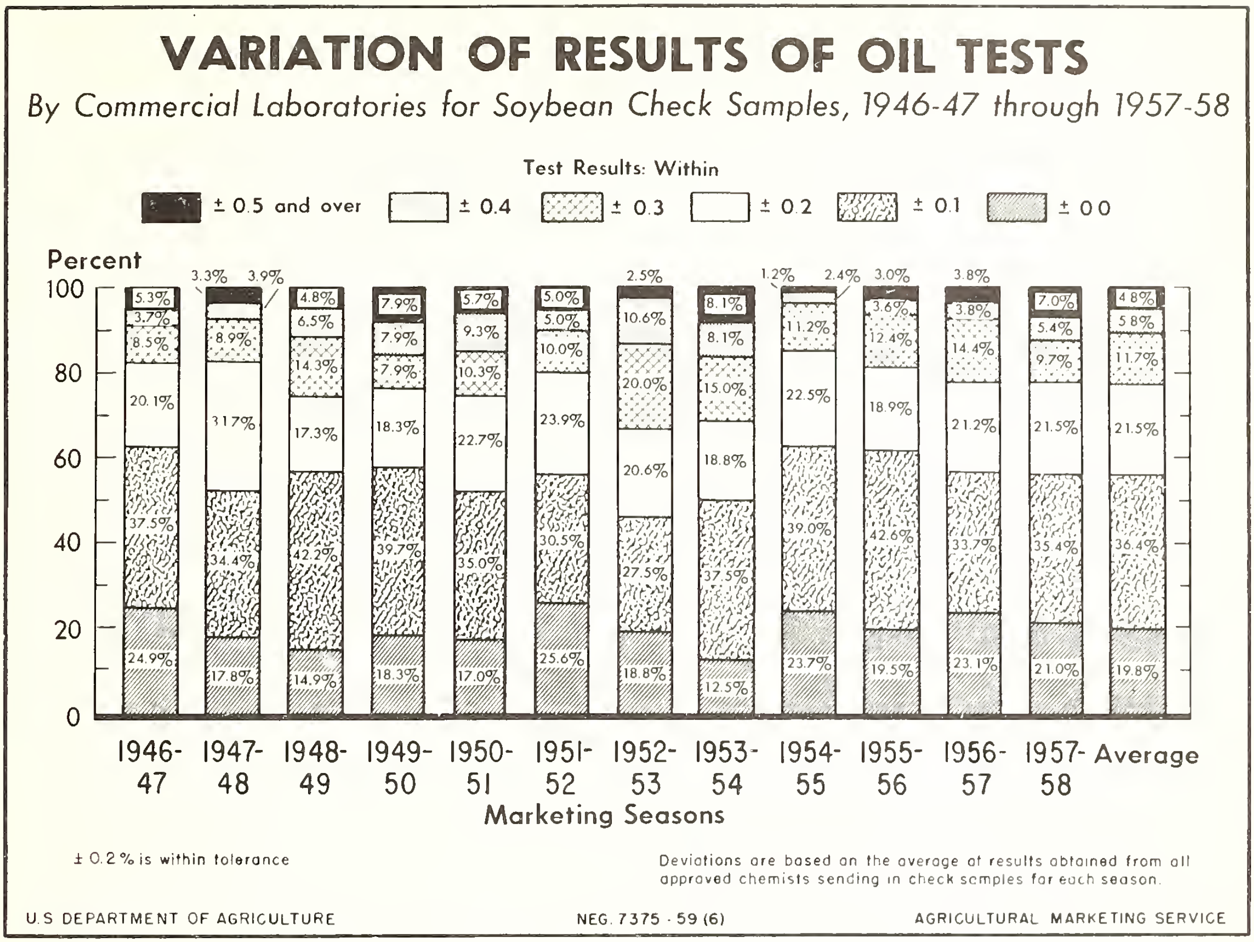

Figure 6

Lack of agreement in oil test results among the different laboratories may, in many cases, be explained by differences in humidity, especially in those cases in which considerable condensation of atmospheric moisture occurs in the oil extracting apparatus. For example, Krober and Collins 17/ have reported data concerning the effect that varying amounts of moisture in ground soybeans have on the amount of lipids extracted by petroleum ether. They have shown that the apparent oil content of soybeans can be affected significantly by the relative humidity of the atmosphere prevailing during the regrinding operations and during the oil extraction of the samples.

IMPROVING DIELECTRIC OIL TEST RESULTS

Greater accuracy can be obtained by making repeat runs per sample. For example, if four repeat runs per sample were made, the differences in oil

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17/ Krober, O. A., and Collins, F. I. Effects of Relative Humidity on the Determination of Oil in Soybeans. Oil and Soap, 21(1):1-5 (1944).

Table 9.--Variation in oil test results obtained by approved chemists for soybean check samples during 12 seasons, 1946-47 through 1957-58

Processing year	Soybean samples	Variation in oil tests 1/	Processing year	Soybean samples	Variation in oil tests 1/
	Number	Percentage point		Number	Percentage point
1946-47	189	0.224	1952-53 ...	160	0.255
1947-48	190	.208	1953-54 ...	160	.330
1948-49	168	.235	1954-55 ...	169	.185
1949-50	164	.264	1955-56 ...	169	.220
1950-51	190	.266	1956-57 ...	159	.225
1951-52	180	.225	1957-58 ...	186	.288

1/ Standard deviation is a special form of average deviation from the mean. It is the quadratic mean of the deviations from the arithmetic mean of the tests. In approximately 2 out of 3 cases the variation in oil content determinations among the laboratories would be within plus or minus the percentage points indicated.

content determined by the dielectric and standard laboratory methods for the two seasons could be reduced by one-half. Thus, if this procedure were followed, the difference could be reduced from 0.516 to about 0.26 percentage point or 0.16 pound of oil for the 1955-56 season and from 0.467 to about 0.23 percentage point or 0.14 pound of oil for the 1956-57 season. 18/ Consequently, if four dielectric oil tests were run per sample from a farmer's lot of soybeans, a degree of accuracy approximating that for the standard laboratory method could be achieved for the lot. 19/

Making repeat runs for each sample, however, would nullify much of the advantage of using the dielectric method. Moreover, the trade would not consider multiple testing of samples as being practical for trading purposes even to obtain much more accurate oil content determinations. Multiple testing of samples, while not a commercially feasible procedure, is discussed here to show that if dielectric oil test results are based on averages of more than

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18/ In 99 times out of 100 the difference for the 1955-56 season would be within 0.67 percentage point or 0.40 pound of oil and for the 1956-57 season would be within 0.60 percentage point or 0.36 pound of oil if 4 repeat runs per sample were made.

19/ If the apparent variations in laboratory oil test results (with which those for the dielectric method were compared) are taken into account, the difference in the dielectric oil determinations, in approximately two-thirds of the cases, would be further reduced from 0.26 to 0.23 percentage point of oil for 1955-56 and from 0.23 to 0.20 percentage point for 1956-57.

one test per sample, greater accuracy could be attributed to the oil tester than that indicated by the test results presented in this report based on one dielectric oil test per soybean sample.

Comparison of the dielectric and laboratory oil test data obtained during the 2 years of this study indicates that the relative efficiency of the dielectric tester can change over time. Therefore, the tester should be checked regularly for proper operation, and adjustments made to maintain efficiency. Also, the soybean samples should be representative of the lot and accurately weighed. Moreover, the solvent used should be measured as accurately as possible. Too little solvent can cause the oil content determination to be too high, whereas too much solvent can cause error in the opposite direction. Furthermore, the cutter blade of the grinder-extractor used in grinding the samples should be kept sharp to provide uniform consistency of the ground samples for testing.

APPRAISAL OF THE DIELECTRIC METHOD

It may seem strange that standards based on factors for grain, which, of course, do not take oil content into account, should be used as the official method in grading soybeans despite the fact that oil content is the principal indicator of soybean value to the processor. However, it would not be feasible to add oil content as a grade factor without a rapid and simple method for determining oil content, accurate enough for trade acceptance and inexpensive enough for application to individual lots of soybeans delivered by the farmer to country elevators.

The dielectric oil test equipment now available for soybean farmers and buyers is quick and relatively simple to use for determining the oil content of soybeans at the time of sale, though improved accuracy is needed. In about two-thirds of the oil tests run for this study during the 1955-56 and 1956-57 marketing seasons, the results obtained by this method varied approximately $\frac{1}{2}$ of 1 percent from the corresponding results determined by the standard method. While representatives of the trade have indicated that this amount of variation is acceptable for certain purposes, they feel that the difference would need to be reduced to about $\frac{1}{4}$ of 1 percent of oil if the dielectric method is to be proposed for use in determining oil content as an added factor in soybean grading.

To provide a basis for comparing the cost per sample for oil tests made by the standard and dielectric methods, a determination was made of the type and cost of the equipment and supplies that can be used effectively by one man running tests by either method during an 8-hour day. From information furnished by firms and individuals who have had experience in the use of each of the two methods, it was estimated that one man with the necessary equipment (costing about $2,200) and supplies (footnote 20, p. 36) can determine the oil content for 24 soybean samples (in batteries of 6) by the standard method in an 8-hour day. But no oil test results would be available before the end of this period. The cost was estimated at $1.19 per sample (footnote 21, p. 36).

It is estimated that one man with the necessary equipment (costing about $1,460) and supplies 22/ can make 55 soybean oil content determinations by the dielectric method in an 8-hour day. The oil test result for the first sample can be available within 15 minutes after the testing has begun. After a few samples are in process of being tested (with several manipulations taking place simultaneously), the results for successive samples in series can be obtained in considerably less time than that (average for the day, less than 10 minutes each). This speed would be important, especially during the busy harvesting season when there may be several loads of soybeans waiting to be unloaded at the elevator. The cost was estimated at 54 cents per sample. 23/

Although these findings indicate that the dielectric method for oil testing is quick, relatively simple to perform, and apparently not prohibitive in cost per sample, further modification of the electronic test instrument and testing procedure is needed to reduce the variation in results to within the indicated range acceptable to the trade. Moreover, it is extremely important that personnel running the tests follow the instructions very closely, as any deviation from them can adversely affect the results obtained. And just as grain inspectors are permitted to grade soybeans officially only after they have demonstrated proficiency in that assignment, the personnel selected to run the dielectric oil tests also should demonstrate their ability to obtain consistent results with the test equipment.

The manufacturers of electronic oil test equipment are continuing to make improvements on the grinder-extractors and the oil-testing instruments as well as refinements in the testing procedure. With the results indicated by this study and with the improvements being made, there is no reason to doubt that continued research efforts will result in the development of an electronic oil tester that will produce results approximating the relative accuracy of the standard gravimetric method. It would then be considered acceptable for use in measuring oil content, and its use could be proposed as an adjunct to the official grain standards in grading soybeans in trade channels beginning at the country elevator. A more accurate appraisal of soybean value would provide the mechanism for more equitable trading in this commodity.

20/ Laboratory equipment for the standard method included: 1 analytical balance, $450; 1 Bauer mill, $750; 4 6-place, electrically heated extraction apparatuses (at $170 each); 24 Butt extractor assemblies (at $10 each) or 24 Soxhlet extractor assemblies (at $20 each); and 100 feet rubber tubing (at 10 cents per foot). Supplies included 24 sheets of filter paper (at $1\frac{1}{4}$ cents each) and solvent (Skellysolve F or equivalent at 1 cent per sample).

21/ This cost included the supplies, labor of laboratory technician (at $2.50 per hour), and overhead costs (at 40 percent of the labor cost per day).

22/ Equipment for the dielectric method included: 1 torsion balance, $175; 1 grinder-extractor, $540; 1 LOS oil tester, $595; 1 extra cup for the grinder, $9.10; 12 graduated cylinders (at $2.10 each); 12 beakers (at 70 cents each); and 1 pressure filter, $123.50. Supplies included: 55 sheets of filter paper (at $1\frac{1}{4}$ cents each) and solvent (Steinlite No. 1 at $16\frac{1}{2}$ cents per sample).

23/ This cost included the supplies, labor of nontechnical personnel (at $1.75 per hour), and overhead costs (at 40 percent of labor cost per day).

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